An End Station for Photoelectron Spectroscopy of Actinide and Other Highly Reactive Samples

Darío A. Arena and James G. Tobin
Chemistry and Materials Science Directorate, Lawrence Livermore National Laboratory, Livermore, CA

David K. Shuh
Chemical Sciences Division, Ernest O. Lawrence Berkeley National Laboratory, Berkeley, CA

Roland K. Schulze
Los Alamos National Laboratory, Los Alamos, NM

Peter Boyd
Boyd Technologies, Livermore, CA

BACKGROUND

For many decades, the actinide metals have been recognized as possessing the most complicated electronic properties and structural phase diagrams on the periodic table [1]. To date, however, detailed experimental data on the electronic structure of elemental actinide samples has been hampered by the difficulty in conducting experiments on these systems. In particular, the kinds of photoemission experiments that are possible only at synchrotron sources, where parameters such as photon energy and polarization can be easily manipulated, have not been conducted in a systematic fashion on the actinide metals. Initial photoemission experiments on plutonium were conducted successfully on the UltraESCA end station of beam line 7.0.1 at the Advanced Light Source [2], and the results were both encouraging and illuminating. Nonetheless, the experiments were challenging and very labor-intensive in part due to the use of the shared user facility at beam line 7.0.1 and they highlighted the need to develop an end station that was dedicated to the study of actinide and other highly reactive samples. This system, the Actinide Spectroscopy End Station (ASES), has been under design and construction over the past year and will be operational within a few months.

DESCRIPTION

The samples in the ASES will be mounted on cylindrical sample pucks of the sort that are commonly used in UHV sample introduction systems. A major limitation of the experiments on the UltraESCA end station was the intricate series of puck transfers required to move the sample from the sample cleaning stage to the analysis position. This is undesirable for two reasons. First, the complicated sample transfer sequence increases the possibility of dropping a puck. More fundamentally, the puck transfer sequence took quite a bit of time, on the order of twenty minutes, and also exposed the actinide sample to unacceptably high ambient pressures of about 10^{-8} torr between the sample cleaning and analysis positions. The ASES was therefore designed so that the sample cleaning and analysis stages are co-linear and the sample moves between the two stages while mounted on a long stroke UHV manipulator (see Fig. 1). Sample analysis will occur in the top chamber. The chamber has access ports for the synchrotron radiation, a dual anode Mg K-α and Al K- α x-ray source, and a Physical Electronics model 10-360 spherical capacitor analyzer for high-resolution electron spectroscopy. The sample preparation chamber is mounted below the analysis chamber and can be accessed by simply translating the sample down on the long-stroke manipulator. The sample can be moved from the sample cleaning position to the analysis position in less than a minute.

The ASES design also incorporates a novel sample introduction system to eliminate the need for exposure of the samples to the atmosphere of the ALS floor and also minimize the degradation of the sample from exposure to atmospheric gases. The samples will be transported to the ALS in vacuum suitcases (see Figure 2) that are small ion-pumped vacuum vessels. The vacuum suitcases will be sealed offsite and can maintain a base pressure of approximately 10^{-8} torr. These vacuum suitcases will be mated to a specially-designed vacuum transfer stage, where the samples will be removed from the vacuum suitcase and placed onto the long-stroke sample manipulator. Upon completion of a set of experiments, the sample will be returned to the vacuum suitcase, and the suitcase will be sealed for transport.

The ASES will contain a number of other design innovations that will facilitate the completion of photoemission experiments on actinide samples. The entire vacuum system can be pumped with only ion pumps. This will be the normal off-line mode of the system so that transfer pumps such as turbomolecular pumps are not used while the system is off-line while waiting for beam time. In addition, the end station contains a number of redundant systems, such as multiple temperature measurement and sample heating stages, so that experiments can continue in the event of such common occurrences such as a broken heating filament or an open connection on a thermocouple. Finally, the ASES is designed with a small form factor so that it can be moved to different beam lines at the ALS and also to allow for transport to the Actinide Chemistry Lab in Building 70A.

[1] See "Challenges in Plutonium Science," in *Los Alamos Science*, vol. 26, 2000.

[2] J. Terry, R. K. Schulze, J. D. Farr, T. Zocco, J.Wills, M. Blau, J. Tobin, K. Heinzelman, E. Rotenberg, D. K. Shuh, O. Eriksson, and G. van der Laan, *under preparation*.

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Principal investigator: Dario A. Arena, Chemistry and Materials Science Directorate, Lawrence Livermore National Laboratory. Email: daarean@lbl.gov. Telephone: 510-486-5584.

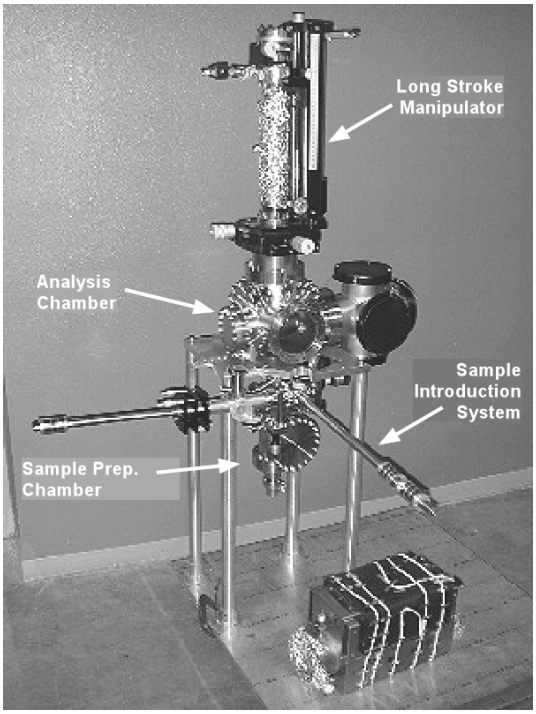

Figure 1: New dedicated Actinide Spectroscopy End Station (ASES). Note the long stroke manipulator, separate sample analysis and preparation chambers, and sample introduction system.

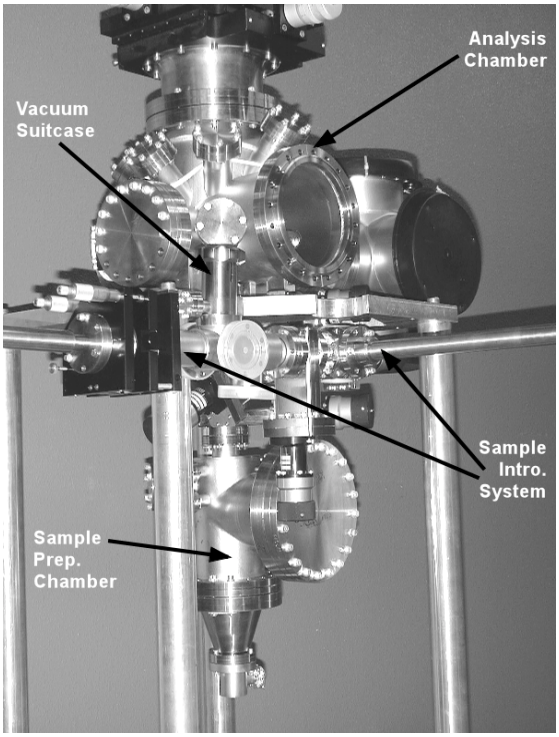

Figure 2: Detail of sample introduction system including the vacuum suitcases used to transport the actinide samples.